THE AMERICAN JOURNAL

OF

OPHTHALMOLOGY.

VOL. XX. MAY, 1903. No. 5.

ORIGINAL ARTICLES.

AN EXPOSITION OF THE PRINCIPLES OF REFRACTION IN THE HUMAN EYE, BASED ON THE LAWS OF CONJUGATE FOCI.

With 17 Original Illustrations.

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IT is a regretable fact that but few undergraduates in our medical schools come to their studies in ophthalmology with such sufficient ground-work in physics as shall allow the professor to assume that their knowlege will enable them to comprehend readily even the simple laws involved in the study of the eye as a collecting refractive system for the formation of images upon the retina. Even those who have gone through the ordinary university or college training have, for the most part, to be taught what optics is necessary from the beginning. It is hoped, and indeed expected, that this will be remedied in the near future; but under any circumstances it will be necessary for the instructor to go over some of this ground in the application of general optical laws to the special conditions found in the eye, in order to make his teaching consecutive and thorough.

Since all the phenomena pertaining to the position and size of the image on the retina and its relation to the object rest upon, and are only to be explained by, the laws of conjugate foci, it would seem that if we could first make our students

thoroughly familiar with these simple laws, by diagrams and models, it would much facilitate their understanding of all the practical problems which arise in the study of the eye as an optical instrument. This, I am fully aware, may be considered as going back to very elementary optics, and repeating what has been said over and over again in our text books, but we must not forget that what has become a very familiar way of looking at the subject to us is still a very unfamiliar way to the average student, who has so many other things to think about; and while it is not possible to make a royal road to knowledge, it is still possible to make the path comparatively smooth and easy to the comprehension of fundamental principles. The conjugate focus is, of course, mentioned often in our treatises and text books, but always in a subsidiary way and incidentally, and not as the bed rock on which the whole fabric of refraction rests. It has occurred to me that such a presentation as is here given might be acceptable to teachers who feel the need of some simple method of explaining the fundamental elements of refraction in all its phases, and it is offered with the hope that it may at least render some slight assistance in their labors. An application of these principles to the details of individual conditions cannot, of course, be attempted in this short essay.

The *laws of conjugate foci*, so far as they pertain to the relative positions of the image and object, are:

1. The rays of light follow the same path going and coming, thus making it possible for the object and image to replace each other.

2. The two foci, representing the object and the image, always move in the same direction. If one moves to the right the other moves to the right also, and *vice versa*.

3. When the object (or image) is situated outside of the principal focus (for parallel rays), the image (or object) is found on the opposite side of the refracting system, and is positive, real and inverted.

4. When the object (or image) is situated within the principal focus (for parallel rays), the image (or object) is found on the same side of the refracting system and is virtual and erect; that is, the rays proceed as if coming from a real object situated at that point.

The operation of these laws is shown diagramatically in Figs. I. and II. (*), where we will follow the object emitting the rays, beginning at infinity on the left and going to infinity on the right.

The object in Fig. I. being at infinity on the left and sending out parallel rays *a a*, has its conjugate focus at the posterior principal focus a^1, on the opposite side of the refracting system O. Infinity and the principal focus are therefore conjugate foci, and both are positive and real.

When the object is advanced to the right to a finite dis-

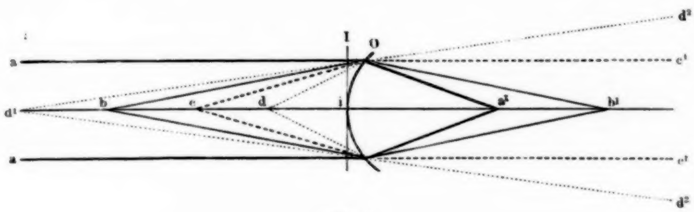

FIG. I.

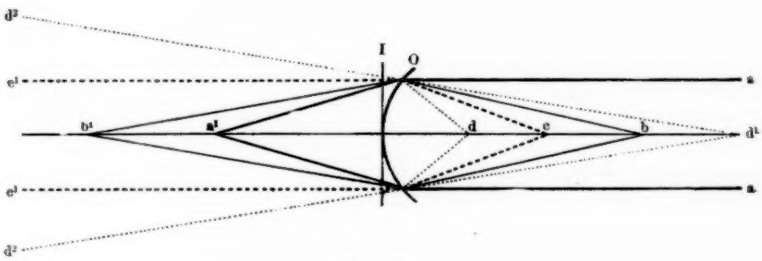

FIG. II.

tance *b*, the conjugate focus, as represented by the image, recedes in the same direction to b^1, and being on the opposite side of the refracting system is still positive and real.

When the object is still further advanced till it reaches the anterior principal focal point *c*, the conjugate focus recedes to infinity on the right as represented by the parallel rays c^1 c^1; the image becomes infinitely large, but being on the opposite side of the refracting surface O is inverted, real and positive.

When the object is advanced to *d*, falling inside the an-

***. For valued assistance in the construction of the diagrams which accompany this paper I am indebted to the well-known scientific and technical skill of Mr. C. F. Prentice, of New York.**

terior principal focus c (for parallel rays), the conjugate focus with its image passes beyond infinity, and the rays become divergent, $d^2\,d^2$, as if they come from a real object d^1, situated on the same side of the refracting medium as the object d. The image d^1 is therefore erect, virtual and negative.

As the object d is still further advanced to the right towards the refracting surface O, the conjugate focus d^1 also advances in the same direction, but at a more rapid rate, until the image finally overtakes the object, and both are merged into one at i in I, which is the principal plane of the system. The object still proceeding in the same direction passes to the *right* of the refracting surface O and finds itself, say at d, Fig. II., and within the principal posterior focus c, for parallel rays $c^1\,c^1$, coming from the left. The conjugate focus has also moved to the right, and according to rule 4 is to be found on the same side of the refracting surface, at d^1; it is negative, and the image is virtual, the rays, $d^2\,d^2$, proceding with a divergence as if they came from a real object situated at d^1. The object still receding to the right from the refracting system, the conjugate focus likewise recedes in the same direction, but at a more rapid pace, until the object arrives at c, the posterior principal focus (for parallel rays $c^1\,c^1$), when the conjugate focus will again find itself at infinity on the left, following the parallel rays $c^1\,c^1$ and becomes real and positive. Proceeding with the object then to b, the conjugate focus advances from infinity on the left to the finite distance b^1, and the image is real. A further advancement of the object along the axis to the right is accompanied with a corresponding advance of the conjugate focus and its image until the object reaches infinity (parallel rays $a\,a$), when the conjugate focus is found at a^1, the anterior principal focus of the system.

Comparing these two diagrams, it will be seen that one is the reverse of the other, and that the object could, with the same results, have been started from the right and moved towards the left, demonstrating rule I. of the laws of conjugate foci, that the image and the object can replace each other.

In studying the phenomena of the dioptric apparatus of the eye, we find that the laws of conjugate foci admirably lend themselves to a satisfactory elucidation of the problems which it is necessary for us to solve in practice.

In making an application of these laws, we shall, for the sake of uniformity and simplicity, consider *that one conjugate focus is permanently fixed on the retina; for it is there that the distinct image must always be formed.* The other conjugate focus, which is the varying one, is at the place where the object must be situated in order that this retinal image be distinct. This place has been called the "far point."

The far point and the retina are, therefore, always at conjugate foci.

Whenever the relative position of the retina and the principal focus of the refractive system changes, either by an increase or decrease in the refractive power of the eye, or an alteration in the distance between the retina and the refractive system, in other words, whenever the conjugate focus, represented by the retina, alters its position relative to the posterior principal focus for parallel rays, so also must the other conjugate focus change its position relative to the refractive system, and always in keeping with the laws of conjugate foci, as above explained.

It has been agreed, by convention, to adopt one single position of the retina in respect to the refracting system of the eye as a standard by which every other position shall be compared. This accepted place is when the retina lies at the focus of parallel rays, the posterior principal focus of its refracting system. *In this standard eye, then, the retina and infinity (from which parallel rays proceed) are at conjugate foci, and the optical condition is called Emmetropia (E).*

As compared with this, the only other possible positions of the retina are two—1, that in which the retina lies outside the principal focus for parallel rays, which is called *Myopia* (*M*), and, 2, that in which it lies in front of the principal focus, called, *Hypermetropia* (*H*).

Every eye in all its states of refraction, static or dynamic, must fall in one of these three categories. It must be borne in mind, in these studies of the static refraction, that the absolute refracting power of the eye is not, as might readily be supposed, the matter at issue at all. We have solely to do with the retina and its conjugate focus. It is a fact which has been demonstrated innumerable times that the actual refracting power in myopic conditions may be lower than in emmetropia, and in hypermetropia it may be higher.

Let us now apply the laws of conjugate foci as above stated to an explanation of the phenomena of the refraction of the eye.

In Fig. III. is shown the position of the retina in relation

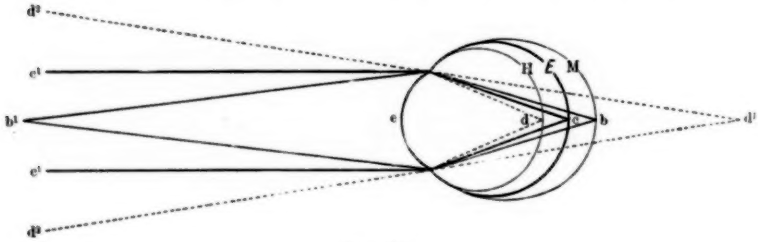

FIG. III.

to the refracting system, in each of the categories of H, E and M, as they are commonly represented, in which the retina *c* lies at the posterior principal focus for parallel rays (*E*), while *b* gives the position of the retina, behind the posterior principal focus, (*M*), and *d* its position in front of it, (*H*).

As, however, according to our manner of considering the subject, the retina is regarded as occupying a fixed position, we can very properly assume that the differences in distance between it and the refracting system of the different categories is attained by a variation in the position of the refracting system itself, as shown in Fig. III*a*, in which H, E and

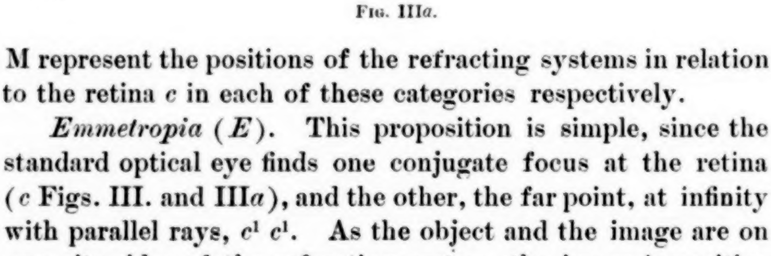

FIG. III*a*.

M represent the positions of the refracting systems in relation to the retina *c* in each of these categories respectively.

Emmetropia (*E*). This proposition is simple, since the standard optical eye finds one conjugate focus at the retina (*c* Figs. III. and III*a*), and the other, the far point, at infinity with parallel rays, c^1 c^1. As the object and the image are on opposite sides of the refracting system, the image is positive and real.

Myopia (*M*). When the retina is located beyond the principal focus of the refracting system *c*, Fig. III., and finds itself at *b*, its conjugate focus, representing the far point, will be found at b^1. These conjugate foci, being on opposite sides of the refracting system, are both positive. It must be evident, from law 2 of conjugate foci, that in proportion as *b* recedes to the right the conjugate focus b^1 will advance towards *e*, and if such a thing were physically possible and the retina *b* could remove to infinity on the right, c^1 c^1 Fig. I., b^1 would be found at the *c*, the anterior principal focus of the refracting system.

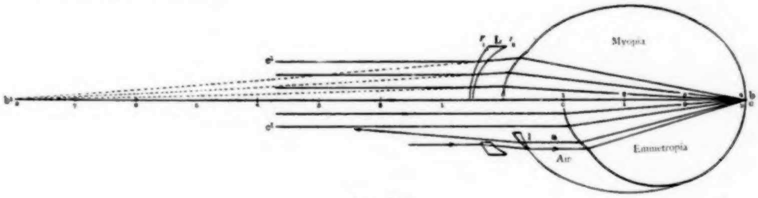

FIG. IV.

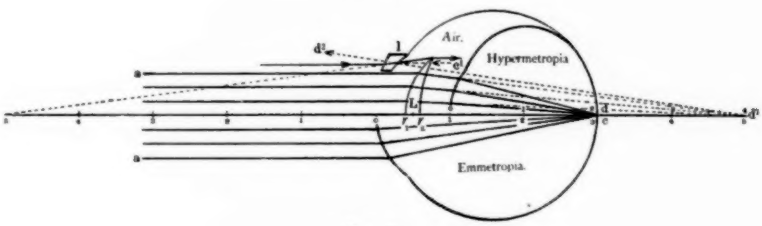

FIG. V.

EXPLANATION OF FIGURES IV. AND V.

These figures showing the relative dioptric values of the emmetropic, myopic and hypermetropic eye, I owe to the ingenious pencil of Mr. C. F. Prentice of New York, who describes them as follows:

"The emmetropic, myopic and hypermetropic eyes are represented as solid bodies of glass with an index of refraction, n=1.5, and anterior refracting spherical surfaces of a uniform radius =1. Introducing these values into the formula, $\frac{1}{f}=\frac{n-1}{n\,r}$, which expresses the refraction for parallel incident rays, our schematic emmetropic eye is found to have a depth of focus on the optical axis =3, (numbers below the optical axis in Figs. 4 and 5.)

"Fig. 4 shows the *emmetropic eye* (lower portion of the diagram), *compared with the myopic eye* (the upper half of the diagram). whose optical axis is longer by a radius of 1; that is to say its depth of focus from the retina, which is common to both, is made arbitrarily =4, (figures above the optical axis). The conjugate focal distance anterior to the cornea of the myopic eye is found by the formula $\frac{n}{e}-\frac{1}{a}=\frac{n-1}{r}$ wherein $e=4$ (with in the eye), and a (in the air), are conjugate distances upon the optical

axis. The anteror conjugate focus is found by this formula to be —8, which being counted from the cornea in the opposite direction to the incident rays is established at b^1, which is thereby the far point of the myopic eye. The correcting concave meniscus L, is arbitrarily placed one half radius in front of the myopic cornea, so that the distance of the center of this lens is 7½ units from its focus, which thus coincides with the far point of the eye at b^1. By making the radius r^2 of the posterior surface of this lens =1 unit, we obtain, through the formula for lenses whose thickness can be neglected, $-\frac{1}{F}=(n-1)\left(\frac{1}{r1}-\frac{1}{r2}\right)$; the value of the radius of curvature of the anterior surface, r^1, =1.36, as carried out in the diagram. The convex meniscus l (a section of which is shown at the lower part of the diagram), which expresses the difference between the refracting power of the myopic and emmetropic eye, is shown to have its anterior surface coincident with the myopic cornea, and hence the curvature of this anterior surface =1, and its focus is =8. The curvature of its posterior surface, r_2, is obtained from the formula $\frac{1}{F}=(n-1)\left(\frac{1}{r1}-\frac{1}{r2}\right)$ and becomes 1.33 as in the diagram.

"Fig. 5 gives, in a similar manner, the comparative dioptric values of the *emmetropic and hypertropic eye*. The hypermetropic eye (upper part of the diagram), being shorter by one unit of radius, its depth of focus is therefore only =2, (figures above the optical axis). Applying the formula $\frac{n}{e}-\frac{1}{a}=\frac{n-1}{r}$, in which $e=2$. we find the conjugate focal distance, $a=4$, which being counted from the cornea in the direction of incidence is located *behind* the eye at d^1, and is therefore the hypermetropic far point. The convex correcting meniscus L is placed one half unit of radius in front of the cornea of the hypermetropic eye, hence its focus will be 4½ units from d^1, the far point behind the eye. The radius of curvature of the anterior surface $r^1=1$, the radius of the posterior surface r^2 will be, according to the foregoing formula, =1.8. The concave meniscus l, expressing the difference between the emmetropic and the hypermetropic refraction, has the curvature of its posterior surface coincident with the emmetropic cornea and its radius =1, and has its focus at $d^1=5$ (figures below the optical axis). Introducing these values in $-\frac{1}{F}=(n-1)\left(\frac{1}{r1}-\frac{1}{r2}\right)$, we find r^1 the curvature of the anterior surface =1.66."

The *degree or amount* of M, that is the difference between E and M, is represented exactly by the difference between the parallelism of the rays, c^1 c^1, Figs. III. and IV. in E, and the divergence of the rays from b^1 in M. This difference is expressed by the power of the convex lens l, as shown in section in Fig. IV, which gives parallel rays a coming from the right a positive focus at a finite distance at b^1 on the left. For example, if the far point be at b^1 10 inches (25 cm.) in front of the refracting system, it means that a lens of 4D positive refracting power is necessary to bring parallel rays a from infinity on the right to a focus at the far point of M, at b^1 on the left. It is commonly said that the myopic eye

exceeds the emmetropic eye in its refraction by that amount. It really, however, only marks the difference in the positions of their two conjugate foci or far points. When, however, it is desired *to convert M into E*, that is to bring infinity on the left in front into conjunction with the retina, it is necessary to render, by the concave lens L, the parallel rays c^1 c^1 artificially divergent as if they came from the conjugate focus at b^1. In the example taken, with the far point at 10 inches (25 cm.), a dispersion (concave) lens of 4D focus placed close to the eye would give the parallel rays c^1 c^1 coming from infinity a divergence as if they came from its negative focus at b^1, 25 cm. in front of it. The focus conjugate to the retina will then have been removed from 10 inches to infinity, the Myopia of +4D will have been neutralized by the —4D lens, and emmetropia will prevail.

Hypermetropia (*H*). In this optical state the conjugate focus, represented by the retina, lies in front of the posterior principal focus of the refracting system at *d* (Fig. III.). Both conjugate foci *d* and d^1 consequently fall on the same side, to the right of the refracting system, and the image d^1 is negative. Since in accordance with rule 1 of conjugate foci it is indifferent in which direction we follow the rays, we will assume, for a simpler demonstration, that the rays start from the conjugate focus on the retina at *d* (Figs. III. and V.).

The rays, then, coming from the retina at *d* do not after refraction by the dioptric apparatus become convergent as in M, nor parallel as in E, but are divergent, d^2 d^2, Figs. III and V, as if they came from the conjugate focus at d^1, which is the far point for that particular optical state.

As *d* recedes from the refracting system towards *c* (Fig. II.) the conjugate focus d^1 also recedes in the same direction, but more rapidly, so that by the time *d* has reached *c*, the posterior principal focus of the system, d^1 has gone to infinity, and emmetropia prevails, since the retina and infinity are once more at conjugate foci. The hypermetropia has therefore disappeared. When, on the other hand *d* moves away from *c* and towards the refractive system, d^1 also advances to the left in the same direction, but at a more rapid rate, and if such a thing were physically possible and the retina

d could reach I, d^1 would also be found there and they would be superposed.

The *degree or amount of H*, that is the difference between the far point of *E* and the far point of *H* in this case is expressed by the power of the concave lens *l* *Fig. V.* which would render parallel rays c^1 coming from infinity on the right divergent, d^2, as if they came from d^1. The far point and the focus of the lens would then coincide at d^1 and both be negative. If, for example d^1 is 20 inches (50 cm.) behind the refracting system, the difference is represented by a concave (dispersing) lens *l* which, placed close to the cornea, will have a negative focus of 20 inches behind the refracting system. As commonly stated, the hypermetropia has 2D of refraction less than *E*, but what is really expressed is the difference in the position of the conjugate foci or far points in the *H and E*.

When, however it is desired to artificially *correct the H*, and bring the far point d^1 back to infinity, it is necessary to render the divergent rays from the conjugate focus d^1 parallel. This is accomplished by a convex lens, L, of 2D, which, placed close to the cornea, has its focus for parallel rays *a a* at d^1. Then, rays divergent from d^1 will be made parallel and the conjugate focus or far point will be removed from that point d^1 to infinity, *a a*, on the left, and emmetropia will prevail. The hypermetropia of —2D has been neutralized by the +2D. lens and is said to be corrected.

THE CONJUGATE FOCUS IN ACCOMMODATION. (A).

In the static refractive conditions we have been considering, the differentiation of the three catègories of *E*, *M* and *H* consists in a determination of the relative positions of the far point and the retina as conjugate foci, the matter of the actual refracting power not entering as a factor. There is however, a state of what is called dynamic refraction in which the eye has added to its refracting power by means of an increased curvature of the lens through a contraction of the ciliary muscle. This increase in refraction serving to adapt the eye to distinct vision at distances within the far point is called the *accommodation* power. We shall find that the laws of conjugate foci apply here as pertinently as we have found them to do in the conditions of static refraction.

When an eye has added to its refracting power, the position of the retina, representing one conjugate focus, remaining unchanged, it is only the position of the other conjugate focus that can be altered, involving a modification in the location of the far point.

As, however, the position of the focus conjugate to the retina in a static refractive condition has been called the *far point* (*punctum remotum*), another name must be used to designate the far point under accommodation. This properly should be termed the *accommodation point* (*punctum accommodatum*) but the term *near point* (*punctum proximum*) has been so long employed that it may be retained as sufficiently descriptive and accurate for practical uses.

We will now examine the effect produced upon the remote conjugate focus by the accommodation in the three categories of static refraction.

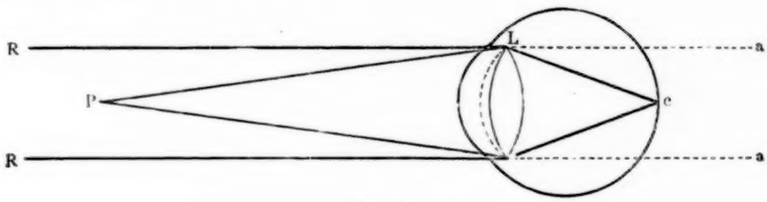

FIG. VI.

A in Emmetropia. In this case the effect of an increase in refraction, the retina remaining fixed, would be to advance the far point from infinity to a finite distance, that is to conconvert *E* into *M*. The amount of accommodation then, that is the refractive power added, would be represented by a lens which placed at L would bring parallel rays *a a* Fig. VI. to a focus at the point of accommodation. If, for example, the accommodation point is at *P*, 8 inches (20 cm) from L, the actual refractive condition would be represented by the value of *M* with its far point at *P*, that is by + 5 D. As this, at the same time, gives the difference between the far point of the emmetropic eye, R, and the accommodation point *P*, the general formula for the amount of accommodation, which is the same in all three categories of refraction, is $A=P-R$; therefore in this special case $A = 5 - \infty = 5D$.

On the other hand, if we know the amount of A, the

position of P is found by the formula; P=A +R: 5+ ∞ = 5D =20 cm.=8 inches.

A in Myopia. In this case the far point is already at a finite distance. The act of accommodation can then only bring the far point nearer to the eye, that is increase the degree of *M*, and the amount of advancement is measured by the difference in the positions of the far points in the two degrees of *M*. Let R Fig. VII. be the far point in a static con-

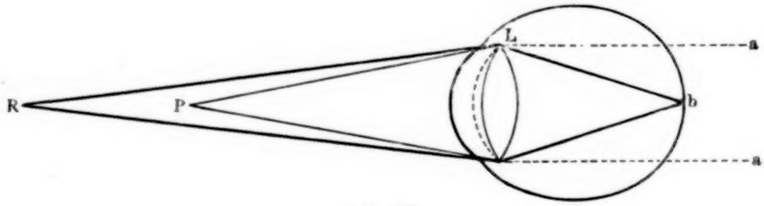

FIG. VII.

dition say at 50 cm. (20 inches) from L, representing 2D of *M*, and P the accommodation point at 10 inches = 4D of M, then since A = P - R: 4 - 2=2D of A. On the other hand, if the amount of *A* and the far point are known, the accommodation point will be obtained by the formula P = A + R; A being 2D and R 2D, P = 4D = 10 inches = 25 cm.

A in Hypermetropia. This case is somewhat different from the other two categories of static refraction, owing to the fact that R is behind the refracting system and has a negative value. In Fig. VIII. R represents the far point of an

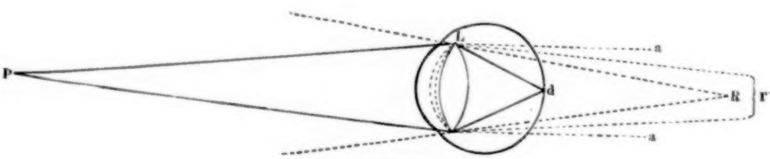

FIG. VIII.

eye with H of 4D, its conjugate focus being 10 inches (25 cm.) behind L. If, by the act of accommodation, a refracting power is added, it will remove the conjugate focus back from R towards infinity, let us say to *r*, at 20 inches behind L. The amount of A will then be measured by the difference in the positions of the conjugate foci R and *r*, that is, the focal distances of the lenses necessary to render rays coming from them parallel. *R* under these circumstances is

represented by 4D and r by 2D; A, therefore = 4–2=2D. The accommodation point has still, however, a negative value, being behind the refracting system. If r be at 40 inches (1 M.) A = 4 – 1= 3D, the accommodation point yet remaining negative. When r reaches infinity A 4 — ∞ = 4D, the H is abolished and emmetropia will prevail. If r be now advanced by a further increase in refraction from infinity to a finite distance on the *left*, say P, the conjugate focus representing the accommodation point becomes positive and a condition of myopia prevails. If this finite distance is at 20 inches (50 cm.) in front of L, the difference between R and P (r being negative and P positive) is represented by R + P. If P be 2D, A=4 + 2=6D, because it has required 4D of A to bring r to infinity and 2D more to bring the conjugate focus to P, 20 inches in front of L. If R is known, P is obtained by the formula P=A+R. In this case R is negative, therefore P= A+(–R)=A—R=6—4=2D=20 inches.

THE CONJUGATE FOCUS IN OPHTHALMOSCOPY.

It was through a recognition of the laws of conjugate foci as applied to the illumination of the eye that the genius of Helmholtz was enabled to give us the ophthalmoscope. It had, seemingly, never occurred to anyone before him, to take account of the fact that the eye was an optical instrument which acted upon the rays of light coming out of it in the same manner as it did on those going into it—and hence the failure to obtain a view of the bottom of the eye after it had been illuminated. If the fundus of an eye, through an illumination, became the source of emitted rays, he reasoned that the rays should be refracted by the optical system of the eye in passing out through it, and would then proceed toward the conjugate focus of the object from which they came; at which focus an image of that object would be formed. If the eye of an observer could be so placed in the path of those emergent rays that its retina would be at this conjugate focus, then the object would be seen in all its details. The theory of ophthalmoscopy as he unfolded it for the first time, consists simply in bringing the fundus of the observed eye and the retina of the observing eye into the positions of conjugate foci.

As the position of the retina of the observing eye in

respect to the far point or conjugate focus of the observed eye must differ in each of the three categories of E, M, and H, the means by which the far point of the observed eye is brought to the retina of the observer must also be different for each. We will now examine these separately, assuming that the observing eye is emmetropic and in a state of static refraction with its far point at infinity.

Ophthalmoscopy in E. In this case the rays emerge from the observed eye parallel, c^1 c^1 (Figs. III. and III*a*,) coming from the fundus *c* of the emmetropic eye E. The conjugate focus is therefore at infinity. As the observing eye placed in the path of these rays also has its far point at infinity the two retinæ will be at conjugate foci, and a clear image of *c* will be formed on the retina of the observer. It will also be noticed that the far points in both (infinity) correspond, which must follow always when the two retinæ are at conjugate foci.

Ophthalmoscopy in M. Here, the far point being at a finite distance, the rays from the fundus emerge convergently towards the conjugate focus at b^1 (Figs. III. and III*a*). The emmetropic observing eye when placed in the path of these rays can not focus them on its retina since it is adapted only for parallel rays. In order that it may so focus them the rays must be made parallel. This can be done by the interposition of a concave lens L (Fig. IV.) of such strength as shall give the rays emerging convergently towards b^1 a parallel direction, c^1 c^1. As b^1 is the negative focus of this lens, its strength also marks the degree of M of the observed eye. By this it will be seen that the ophthalmoscope becomes an optometer for measuring the degree or amount of M. Example: If the retinæ of the two eyes are brought into the positions of conjugate foci, as indicated by the formation of a clear image of the fundus of the observed eye on the retina of the observing eye, by a —4D lens placed close to *e*, behind the ophthalmoscope, we know that this lens has rendered parallel the rays converging towards b^1, which is the far point of the observed eye, and at the same time is the negative focus of the lens, namely 10 inches, which is 4D. This lens of —4D, through which the fundus is seen clearly, is therefore the correcting lens of the M.

Ophthalmoscopy in H. In this catagory where the far point is behind the refracting system at d^1 (Figs. III. and IIIa) the rays from the fundus emerge divergently, d^2 d^2. The emmetropic observing eye placed in the path of these divergent rays can focus them on its retina only after they have been rendered parallel. This, however, may be accomplished by the interposition of a convex lens L (Fig. V.), whose focus for parallel rays, a a, is at d^1. The two retinæ are then placed at conjugate foci (infinity) and the details of the fundus of the observed eye are distinctly pictured on the retina of the observing eye. Example: The details of the fundus are clearly seen through a +2D lens. The conjugate focus of the observed eye is then 20 inches in front of the lens at d^1 behind the refracting system. Neglecting any difference between the eye and the position of the lens, the far point of the eye will fall at this focus, and the H will be 2D.

When the observing eye is not emmetropic, the conditions are somewhat changed, but the law still holds, and it is yet possible for an ametropic eye to see the fundus of another ametropic eye distinctly while both are in their static refractive state. This can only occur, however, when the far points of the two eyes happen to fall at the same conjugate focus. Example: Suppose that the far point of the myopic eye, b^1 Fig. III., is 60 cm. in front of e. If now a hypermetropic eye with its far point at 50 cm. behind its refracting system, d^1 Fig. IIIa, were placed 10 cm. in front of this eye, the far point of both would fall at the same place, that is 60 cm. in front of e, the two retinæ would then be at conjugate foci, and the image of the one would be clearly pictured on the other. The fundus of a myopic eye is the only object in nature that a hypermetropic eye can see without the exercise of its accommodation power, since nowhere else in nature do we have convergent rays.

On the other hand, and similarly, a myopic eye with its far point at b^1 100 cm. from e, Fig. III., placed 10 cm. in front of a hypermetropic eye with its rays coming from the retina divergent, d^2 d^2, as if they came from its far point, d^1, Fig. IIIa, 90 cm. behind its refracting system, will have a distinct view of the fundus d, since the two far points b^1 and d^1 will then fall together and the two retinæ be at conjugate foci.

If the observing eye of either category be possessed of accommodation power it is still possible to bring the far point to the same position as that of the observed eye, provided the latter has a conjugate focus farther from the eye than the former. Thus, an emmetropic observing eye can, by advancing its far point from infinity to a finite distance in front of it, bring this conjugate focus to the negative far point of a hypermetropic observed eye; and a myopic observing eye by increasing its myopia through its accommodation and thus advancing its far point, can bring its conjugate focus to fall at the negative far point of a hypermetropic eye of a higher degree than its own M; and the hypermetropic observing eye can, through its accommodation, bring its far point from a negative position back to infinity, where it will be at conjugate focus with the emmetropic eye, and by a still further increase of A can bring its far point to a finite distance that shall correspond to the far point of another, though less, degree of hypermetropia. In practice, however, it is always best to render the observing eye emmetropic by means of suitable correcting glasses.

This method of ophthalmoscopy in which the two retinæ are brought into the positions of conjugate foci, and the one eye looks directly into the other is called the *direct method*, and as the objects at the fundus are seen in their natural positions the image is said to be *erect*.

Ophthalmoscopy by the Indirect Method. In accordance with the laws of conjugate foci, there must be formed in the air at the far point of an illuminated myopic eye, an inverted image of the fundus of that eye in all its details. If an observer places himself at a sufficient distance from this aerial image so that his far point, either static or by accommodation, shall coincide with this image he will be able to see it distinctly. This principle is used in another method of ophthalmoscopy, which is called the *indirect* method, since it is the image of the fundus of the eye under observation and not the fundus itself which is observed; and since the image is formed *inverted*, it is so-called in contradistinction to the erect image just described. This is only practically possible of course in myopia of high degrees, where the far point is very near the eye under observation. It is possible, however, to render, arti-

ficially, any eye myopic and bring its far point close to the eye by the inter-position of a strong convex lens (usually about 20D), in the path of the emergent rays. This will bring the conjugate focus of an emmetropic eye with an inverted image of the fundus to two inches in front of the lens. Another emmetropic eye at a distance of 18 inches will then be able, by means of its accommodation, to bring its far point to the position of this image, and the image of this image will thus be pictured on its retina. The position of the image will be closer to the lens when the rays come from the eye under observation convergently as in M, and farther when they come divergently as in H; the exact position in any case depending, of course, on the position of the conjugate focus of the eye that is being examined.

THE CONJUGATE FOCUS IN SKIASCOPY (THE SHADOW TEST.)

The laws of conjugate foci as we have found them to apply in all the foregoing methods for determining the optical condition of the eye, hold equally good in this method, though we shall encounter some differences in their application. While in the direct method of ophthalmoscopy, for example, the observing eye seeks to have an image of the fundus of the eye under observation pictured distinctly on its retina, in skiascopy, the details of the fundus are not desired, and the object of observation is the shadow edge of an aerial image* of a bright spot, which is thrown by the ophthalmoscopic mirror on the fundus of the observed eye.

This aerial image, real or virtual, being formed by the refracting system of the eye, lies necessarily at the conjugate focus of the fundus. That to which the observer chiefly directs his attention is the apparent movement of the shadowy edge of this bright spot across the pupillary field of the observed eye as compared with a rotation movement of the mirror giving the illumination. Simple as the method is in practice, its optical principles may seem, at first sight, somewhat complicated, but they are easily resolvable by the laws already exposed. The phenomena differ as a concave or plane ophthalmoscopic mirror is employed. We will consider those with *the plane mirror* first.

*For this reason the incorrectness and absurdity of the term "retinoscopy" must be apparent.

When a plane mirror *m* Fig. IX. is used, the real *source of illumination* is an image L^1 of the flame L situated as far behind the mirror *m* as the flame L itself is in front of it. This *flame image* L^1, in keeping with the well-known laws of reflection, *always moves in a direction opposite to that of the*

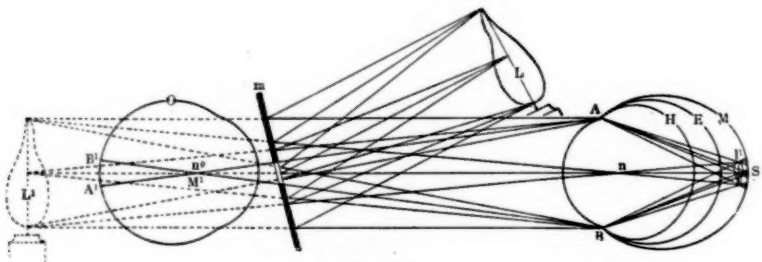

Fig. IX.

mirror rotation; when the mirror is rotated to the right, the flame image moves to the left, and *vice versa.* The *spot of illumination* S, made by this flame image on the fundus of the eye under observation by its refracting system, is positive and inverted, the same as l^1 which is the intraocular image of L^1, and therefore must *move in a direction the opposite of its object, the flame image* L^1; when the flame image moves to the left, the bright spot moves across the fundus to the right, and *vice versa,* that is *in the same direction as the mirror rotation.* When in its turn this *bright spot becomes the object* and a source of illumination on the fundus, *an image of it, real or*

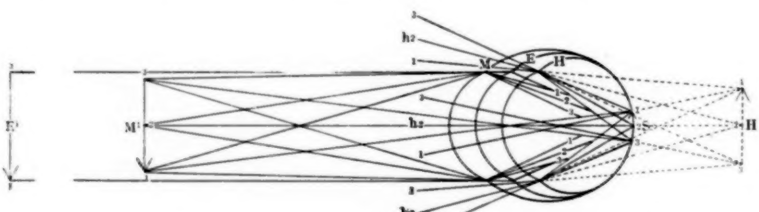

Fig. X.

virtual, is formed by the refracting system at the conjugate focus of the eye.

When the eye is myopic, M, Fig. X. this aerial image of the bright spot S is formed, of course, at a finite distance, the far point of the eye, and is positive and inverted, M^1. When the eye is emmetropic, E, this image lies at infinity, E^1, also in

front of the refracting system and is likewise positive and inverted. When the eye is hypermetropic, H, with its conjugate focus behind the retina and on the same side of the refracting system as the bright spots on the fundus, the image H^1 is virtual and erect, the rays, h^2 h^2 h^2, coming from the eye divergently as if from a real object at its negative far point H^1.

The *movements* of these images in respect to the movements of the object S will be as follows: In E and M, the movements of E^1 and M^1 will be *against* the movements of S, being on opposite sides of the refracting system from S, and therefore *against the mirror rotation*. In H, on the contrary, the movement of H^1, it being on the same side of the refracting system as S, will be in the *same* direction as S and also in the *same direction as the mirror rotation*.

The apparent *direction of movement to the observing eye*, placed in the path of the rays emerging from the observed

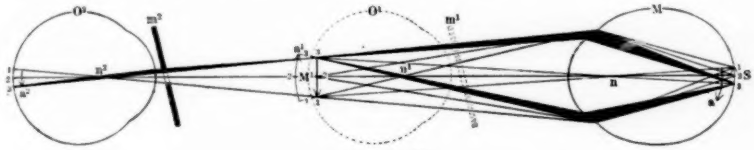

Fig. XI.

eye, however, will depend on the position of the nodal point of the eye in relation to the conjugate focus of the fundus of the observed eye—that is, on whether the observing eye receives rays which come from a real aerial image of the bright spot formed in front of its nodal point, or rays which proceed from the bright spot to form an image behind its nodal point by its own refracting system.

When the conjugate focus or far point of the observed eye, M, Fig. XI. falls *behind the nodal point* n^1 of the observing eye O^1 there is formed there a real and inverted image M^1 of S, which is positive. Now this image may be anywhere between n^1 and infinity behind O^1, depending of course upon the refractive condition of M or the position of O^1 in respect to M. But within these limits no matter where it is formed, whether on the retina, in front of, or behind it, its movements, as perceived by the retina of the eye O^1, are always in the same direction, and just as it would perceive the motion of any object in space in front of it. Though

this is called the *erect* image, it is really formed inverted on the retina, just as the images of all objects in front of the eye are, but in accordance with the law of projection they are perceived as erect, and all movements of S to the right are perceived by O^1 as to the right and *vice versa*, and of course *with the mirror rotation.* The relative rate of motion of the image M^1 as compared with the mirror rotation, and the distinctness of the shadowy edge of the image of the bright spot S, must differ as M^1 is removed backward from n^1, but this does not affect the general direction of the movements of M^1 as perceived by O^1. The observing eye, therefore, will bring parallel rays forming E^1 Fig. X., divergent rays h^2 h^2 h^2 and rays convergent to all points *beyond the position of its nodal point* n^1 Fig. XI. to a focus somewhere behind its nodal point, and in all these conditions the apparent movement across the pupil will be *with* the *mirror rotation.*

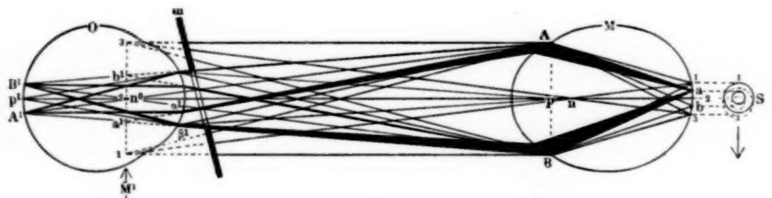

FIG. XII.

When the *conjugate focus falls in front of the nodal point* n^2 *of the observing eye* O^2 Fig. XI., there is formed there a real inverted image, M^1, of the bright spot S. This image being on the opposite side of the refracting system of M moves always in a direction the *opposite of* S, *and likewise of the mirror rotation.* When S moves down in the direction of the arrow a, the image M^1 moves upward in the direction of the arrow a^1. The observing eye O^2 will perceive this movement exactly as it would the movement of any other object moving in the same direction in front of it. Hence in O^2 the shadow moves *against*, whereas in O^1 it moves *with* the mirror.

When, however, the observing eye O Fig. XII. is so placed that the *conjugate focus of the observed eye, M, falls exactly at its nodal point* n^0 *there is no movement observed,* but only a diffuse steady illumination with no outline, however extensively the mirror is rotated. The reason for this is as follows:

As we have seen, the flame image L^1 Fig. IX. of a certain magnitude has always an image l^1 of a definite and proportionate size, made by the refracting system of the observed eye. The pencils forming this image make the bright spot S on the fundus, which is always blurred in outline except when l^1 happens to fall exactly on the fundus. So long as the pupil of the observed eye is fully illuminated during a rotation of the mirror, there is formed, by the refracting system of this eye, an image 1 2 3, M^1 Fig. XII. of the bright spot S at the nodal point n^0 of the observing eye. This image is always larger than the hole in the mirror, (the latter has been purposely exaggerated in the drawing). Now in order that any specific direction of movement be noted it is necessary for the shadowy edge 1-3 of the image M^1 of the bright spot S, to pass across the pupil of the observed eye. Hence the appropriateness of the term Skiascopy (σκια, a shadow, and σκοπειν, to examine).

In the case where the image M^1 falls at the nodal point n^0, the image of the upper edge, 1, of S falls at 1 of M^1. The pencils of light which go to form the image of 1 at M^1, however, are cut off by the mirror surrounding the sight-hole and do not enter the eye O at all, and therefore no image of the edge of the bright spot S is perceived. It is only the pencils coming from *a* in S, much within the limits of 1, that pass along the lower edge of the sight-hole and enter the eye O to form an image at a^1. When the bright spot S moves, say, downward in the direction of the arrow, *a* and 1 move downwards also, synchronously, another point between *a* and 1 taking the place of *a*, which will still form its image at a^1. But no movement downward of S, with a full illumination of the pupil, is sufficient to bring 1 down to the position occupied by *a*, and have its image at a^1, within the eye O. The same holds good also in the upward movement of the points *b* and 3, on the lower limits of the bright spot S, 3 never reaching up to the place occupied by *b*. Consequently the shadowy edge 1-3 of the bright spot S can never have its image within the eye of the observer O, and therefore it can never be seen to pass across the pupil, to whatever extent the mirror may be rotated. As some point of S always has its image at M^1, there is always a steady illumination perceived by O during all mirror rotations.

Those pencils of light from a of the bright spot S which are projected to A and B, marking the outline of the pupil of the eye M, are directed, after their refraction, to a^1 and β^1. After entering O these rays are brought by its refracting power not to a^1, but after crossing each other to the points A^1 and B^1, on the secondary axes A^1 n^0 A and B^1 n^0 B, which pass through the nodal point n^0 to corresponding points A and B of the pupil of M. As these converging pencils, refracted at a^1 and β^1, cross each other within the eye to reach the points A^1 and B^1, they do not unite anywhere to form an image of a of the bright spot S. They simply become widely separated pencils, falling on opposite sides of A^1 p^1 B^1, *which itself becomes the image of the pupil* A p B of M; the observing eye in this method of examination always accommodating for the pupil of the observed eye. The points A^1 p^1, B^1 of O are conjugate to the points A, p, B of M, respectively.

Expressed in simple terms, a and b have their conjugate foci at a^1 and b^1 of M^1, situated at the nodal point n^0 of O, while A B, the pupil of M^1, has its conjugate focus and image at A^1 B^1 of O. On comparing diagrams XI. and XII. it will be observed that the pencils from 1 and 3, corresponding to the shadowy edge of the bright spot S, enter the observing eyes O^1 and O^2 of Fig. XI. through the nodal points n^1 and n^2 to form their images 1 and 3 in each eye respectively, whereas in Fig. XII. these pencils from the shadowy edge of S never enter the eye, being cut off by the mirror, so that no image of them is formed in the observing eye.

It will be seen from this that the nodal point of the observer's eye is the point of reversal from the movement with, to the movement against, the mirror rotation; making the position of the observer's nodal point in relation to the conjugate focus of the observed eye, the key to the situation.

(*Continued next issue.*)

REPORT OF SEVEN EXTRACTIONS WITH HAAB'S ELECTRO-MAGNET.

By N. J. WEILL, M. D.,
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WHILE extractions of iron or steel from the interior of the eye with the Haab Electro-Magnet are frequent, yet nearly every case presents something different from the preceding one.

Occasionally we see cases of injury to the cornea and lens of years' standing made by splinters of iron or steel, the Hirschberg magnet having been used, now in the state of *siderosis bulbi*. Evidently the small magnet was not strong enough to extract these splinters, when its point was sunk into the eye to or even *beyond* the posterior lens capsule. Oculists who use the small magnet *exclusively* have told me that when iron or steel was lodged within the eye through a corneal wound, it rarely penetrated to the vitreous. The giant magnet teaches me, that this is not the rule but the exception—most splinters lodging in the eye are found in the vitreous. In thirteen[1] of my cases the splinter was located once in the anterior chamber, twice in the lens, and ten times (77 per cent.) in the vitreous. In nine cases (69 per cent.) the wound was corneal, in four scleral. My results thus far are: enucleation in one case; shrunken, blind, quiet eye in three; traumatic cataract in five, three of which are operable and two are doubtful, in the one the pupil cannot be dilated (Case VI. of this series) and the other I have not been able to examine recently (Case I. of this series); and normal or nearly normal vision in four (one after needling operation[2]). What a boon this giant magnet is, locating and extracting deeply-seated splinters almost as easily as those situated in the anterior chamber or lens.

In the extraction of splinters from the eye with the giant magnet, it seems to me, we cannot do better than follow the rules laid down by Haab.

It is only a few months[3] since I published a report of five (5) cases of extraction, where I had used Haab's magnet, so that my only excuse for this paper describing the course of seven additional cases, is to bring to the attention of every oculist the advantages of the giant magnet. Its use is not limited to the eye, but with it we can locate and remove small

particles of iron or steel from *other* parts of the body much handier than with the forceps.

CASE I. July 8, 1902, J. H. æt 23. About 2½ hours before injured his right eye while chipping.

Examination of Right Eye:—Vertical linear wound of more than the lower half of the cornea. An iridectomy was made by the splinter as regular as scissors can cut it. Cataracta traumatica. With the strongest current and with the point of the magnet one cm. from the center of the cornea, the splinter pushes its way through the lens, and is then extracted through the original corneal wound with the weakest current. The splinter is 7x6x¼ mm. and weighs one grain. Adherent to it, with the loupe, a few cilia can be seen, which it must have taken into the vitreous with it when entering the eyeball. May be it deposited a cilium in the vitreous!

July 9, 1902. Eye is doing well.

March 28, 1903. From one, who saw this patient this day, I learned that no secondary operation had yet been executed.

CASE II. September 5, 1902, J. C. M. æt. 21. While striking a wedge with a hammer about 2½ hours ago, something hit the right eye.

Examination of Right Eye:—Blood oozing is from a horizontal linear wound about 5 mm. in length, in the posterior temporo-ciliary region. Vitreous bloody. With the strongest current I extracted through the original gaping scleral wound a piece of steel 4x2x1½ mm., weighing one grain. I sutured the wounded sclera.

September 27, 1902. Healing prompt. T—1 to —2. Pupil reacts promptly, directly and indirectly. Projection normal. Starts to work.

October 16, 1902. Right eye violently red and painful. Lower iris drawn in. T—3. Scleral scar drawn in.

March 16, 1903. Right eye quiet since about November 10, 1902. T—3. Left eye normal.

CASE III. October 11, 1902. M. D. æt. 33. It is about 5 hours since he was chipping a casting when his left eye was hurt.

Examination of Left Eye:—Vertical wound of lower cornea with iris and swollen lens in the same. A glittering mass is visible deeper in the lens. A splinter 5⅛x3½x2 mm.

was extracted through the original corneal wound with the strong current.

October 22, 1902. On account of increased tension I tapped the anterior chamber and allowed much of swollen lens to escape.

March 28, 1903. He has used atropin constantly since injury. Cataracta secundaria fairly dense. Tn. Projection normal. I expect to do needling later.

Case IV. November 18, 1902. E. D. æt. 14. In hammering a nail 7½ hours ago something hit his left eye.

Examination of Left Eye:—Small wound of the limbus corneæ below and a glittering mass on the iris in the lower anterior chamber. I extracted the same through the original wound. It carried a little iris with it into the wound. It would have been better to have made a new corneal incision above and thus avoided carrying the iris into the wound. The splinter is 2 mm. long and weighs about one-half grain.

November 24, 1902. From his physician I learned that the healing was uninterrupted.

Case V. January 31, 1903. C. J. O. 39 years. On January 30, 1903, while chipping face of a stairway something struck his right eye. He immediately went to an oculist, who put the point of a small magnet through the wound into his eye, but found no iron.

Examination of Right Eye:—Lids somewhat swollen. A healing wound about 6 mm. long in naso-ciliary region. Pupil medium wide, from drops used hourly at home. Iris discolored greenish (copper corrosion). A yellowish red mass in lower temporal vitreous. With the strongest current in the direction of the center of the cornea, about 10 cm. from the point, patient has a sharp pain over the middle of the upper lid and hyphæma appears from lower temporal iris, which bulges forward. I cannot get the corpus alienum through the pupil as it catches in folds of the iris. I made an incision in the temporal limbus corneæ and a small iridectomy. After enlarging the corneal incision I succeeded in extracting a bronzed cast iron splinter, 7x5x2 m.m., weighing 3¼ grains.

February 23, 1903. Healing prompt. Tn. Has annoying flimmering before eye.

March 28, 1903. About one week ago the eye was red

and painful, is now quiet, but shrinking. T—3. The original ciliary wound is drawn in.

Case VI. March 11, 1903. A. J. McM. æt. 42. About 12 hours before, while chipping, injured the left eye and now cannot see anything. The right eye was injured 15 years ago by an explosion.

Examination of Left Eye:—Semi-circular wound in upper nasal cornea. Cataracta traumatica. With strongest current 6 to 7 m.m. distant from the center of the cornea, the patient has a sharp pain in the eye and hyphæma from the lower iris is apparent. I enlarged the original corneal wound. With the eye directed downwards, the magnet point on the wound, I extracted the splinter. It is coated with a sticky, clear substance (lens or vitreous), measures 5x3x2 mm. and weighs one grain.

March 31, 1903. Pupil does not respond to abundant atropin. Cataracta traumatica.

Case VII. March 16, 1903. H. F. æt. 19. While forging March 12, 1903, thought something struck his left lower lid. Next day he noticed the sight was impaired.

Examination of Left Eye:—Eye quiet. Small corneal scar upwards about one millimeter in length, wound through lens with posterior cortical cataract. With ophthalmoscope in indirect picture, three papilla breadths below the papilla, in the vitreous, just in front of the retina, there is a silvery triangular piece of steel. It is about one-fifth the size of the papilla. With the strongest current, the point almost touching the center of cornea, the splinter is brought behind the lower iris, which it pushes forward before it. I could not bring it through the pupil with weaker currents. I made a small iridectomy downwards and applied the magnet point to the incision in the lower limbus corneæ. The splinter must have slipped through the incision *unseen*, as the magnet thereafter was absolutely negative.

March 20, 1903. Wound closed. Lens becoming more opaque. I tried the magnet again with the same negative result.

Haab has said that one cannot get a magnet too powerful, applicable to all cases, and this appears correct. Further, it is an established fact, that a foreign body once having become "fixed" in an eye, no magnet that has yet been devised will

extract it. In this connection I cite the following recent experience:

March 28, 1903. H. I. G. æt. 43, is referred to me because his left eye, for the past two days, has been red at times and "waters" much, especially when his head is held at a certain angle.

HISTORY:—This eye was injured 2½ years ago by a splinter from a file, which his helper struck with a mall. The patient says the piece of the file, which hit his eye, was about the size of a small grain of wheat. A small hand magnet charged with 110 volts, direct current, was tried at that time with negative result.

Examination of Left Eye:—Vision which I am informed was $^{20}/_{20}$ a month after the injury is now $^{20}/_{50}$. The eye is without external inflammation. The original wound was in the nasal limbus corneæ. Behind this there is a hole in the iris and a segment of opaque lens. The vitreous is cloudy and the papilla seen with difficulty. I ordered atropin to be instilled six to eight times daily.

March 30, 1903. The eye feels good, has not "watered" or been red since atropin has been used. With dilated pupil the lens in general is somewhat hazy, which shows that a lens once injured always sooner or later becomes entirely opaque. To-day the vitreous is much clearer and the papilla quite distinct. In the lower nasal retina a shining foreign body, the piece of steel, can be seen. It is about the size of the papilla. A retinal vein passes undisturbed *in front* of it. The *appearance* of this piece of steel, after being located in the retina 2½ years, is precisely that of a fresh splinter. In the place of retinal hæmorrhages there is a small heap of brown pigment in the retina just above the corpus alienum.

Magnet Test:—The strongest current applied to the cornea has absolutely *no* effect on the splinter. If this eye continues to annoy the patient, I shall attempt to dislodge the splinter by applying the current directly over it.

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b. Two-fold use of Haab's Electro-Magnet in Eye Surgery. Pennsylvania Medical Journal, Pittsburgh, Pa., August, 1902. (Five cases).

2. Case IV. under 1*b*.

3. 1*b*.

DISCUSSION ON DR. ALT'S PAPER ON EPISCLERITIS.

(See page 101.)

Dr. D. S. Reynolds, Louisville, Ky.—I think one of the unfortunate things in considering this subject is the nomenclature. "Episcleritis" does not mean anything except inflammation on top of the sclera. "Epi" means upon. Episcleritis would necessarily mean something external to the sclera. I watched closely the description and Dr. Alt describes scleritis all the time, and if I caught his meaning, I would say it is the opinion of the writer that scleritis nearly always begins within the walls of the sclera. As the sclera is not disposed in layers, I cannot conceive of a superficial or deep-seated scleritis. It is made up mainly of heterogenons connective tissue fibres, and at the points where the wall is perforated by nerves and blood vessels the nodular masses described by Dr. Alt occur. When you study the course of syphilitic disease in its remote manifestations—that is to say, inherited syphilis—it will be observed that the circumscribed organic structural changes accompany the course of the blood vessels. They have their origin in those parts where there is strong resisting tissue. Here is most likely to be the seat of gummatous deposits. I think a large proportion of the cases are inherited syphilis, beginning as a gummatous formation on the uveal surface. I have a large mass of clinical notes on these cases, and I cannot recall from memory an instance that was not seen in a syphilitic subject. I have not seen it in acquired syphilis, but in children the subjects of inherited syphilis, innumerable times. I have had the same experience in the treatment of scleritis as in the treatment of inherited syphilis in other parts of the body. I employ mercury in small doses, giving strict attention to diet and habits of life, with the design of improving the general condition of the patient. I believe that a great deal depends upon nutritious foods, and the use of mercury in small doses will terminate nearly all cases of scleritis.

Dr. J. O. Stillson, Indianapolis.—This is a very interesting subject and I can but express my high appreciation of Dr. Alt's admirable paper. I feel when I hear him read a paper—and I feel it more than ever this morning—under ob-

ligations to him for the clear and charming manner in which he gives us the picture of this most distressing and unsatisfactory disease. We have all met this disease in the course of our practice, I dare say, and if the experience of the other gentlemen has been anything like my own, I am sure they can bear Dr. Alt out in this seeming quandary as to what the disease really is and what really is the rational method of treatment. It will not do for us to start out upon the gouty and rheumatic diathesis, as we are so prone to do, to clear up the diagnosis, to understand this disease, because that standpoint will fit too many other obscure cases. It will not do for us to classify this as a *terra incognita*, because we are too well acquainted with the land marks and the tissues here. It will not do for us to hold up our hands and declare it is incurable. Eighty per cent of the people have gout or rheumatism, that is, are of a lithic diathesis. Eighty per cent of the people who live to be along towards the fifties have rheumatism, and if we are going to take that as a basis, we can make up our minds we can explain anything on the uric acid diagnosis. It is like the old explanation of glaucoma: we can easily explain glaucoma if we want to take the backward track. But when we come down to the fact that the majority of men (about three-fifths) are hypermetropic anyway, then it will not do to use hypermetropia as a cause of glaucoma. We see it more in hypermetropic people because there are more hypermetropic people. And so, too, on this line, we may well say that we see more episcleritis in rheumatic or gouty people than in those free from this disease, because more people have this disease than do not. So to my mind it is a co-incidence rather than a cause. I do not agree with Dr. Reynolds about it being in so many instances a specific disease. I used to feel that way myself, but I know that I have seen cases where this could not be accepted. I studied a case about a year ago in connection with Dr. Stevenson of Ft. Wayne, in which we found nothing that would lead me to believe it was syphilitic.

Dr. J. A. Donovan, Butte, Mont.—I have had quite a number of cases of this disease and never have been able to connect it with syphilis either directly or indirectly, and I look for it in my patients. Some time ago I had two patients at the same time who had a peculiar odor to the breath

in a warm room, which struck me as peculiar. I noticed the same odor on another patient, and ever since I have made the diagnosis from the characteristic odor of the patient. The last half dozen have had a peculiar odor perceptible. The last I had was a lady who had a history of having been treated for three years by local treatment. I began with one-fourth grain calomel until she had taken three grains every day, and after that phosphate of soda. These are the only patients with whom I have had satisfactory results in this trouble, and so far every one has recovered within five to six weeks.

Dr. Geo. F. Suker, Chicago.—I think this is a very opportune time to discuss episcleritis and scleritis I am sorry Dr. Alt did not say anything definite regarding sodium salycitate. I have several cases at the present time in which part of the cornea is involved, and I agree that we usually have an inflammation of the uveal tract. I have a patient who has had episcleritis for a year, with the characteristic bluish color, and nothing relieved her. As a last resort I started her on the salicylates; and as I am a firm believer in large doses, I ran up to 150 to 180 grains per day. Her pain subsided and she is recovering nicely. She is still taking 60 grains per day with plenty of water. I make the patients take as much water as the skin can hold while taking these large doses. In addition to these large doses, I use the atropine and hot fomentations. This person is making a very fair recovery; the nodules are disappearing, but the bluish cast remains. As to the staphylomatous nodules about the eye, I fully agree with the doctor. I saw one case quite recently with Dr. Beck which has now developed not only a staphyloma but also a glaucoma. She had terrific pains and nothing did any good until she had the large doses of the salicylates. As to the etiology, whether rheumatic or syphilitic, I agree that we can't tell what it is. Some seem to be one and some the other. If you give large doses of sodium salycilate you can possibly exclude a syphilitic basis. Still even in specific cases it is efficacious. Whether the uveal tract is the basis or not, I think Dr. Alt will clear this up for us some time.

Dr. C. L. Minor, Springfield, O.—Recently two young ladies, aged respectively 18 and 20, came to my office with in-

volvement of the sclera. I referred them to the family physician for examination. There was no history of syphilis in either family and no gouty diathesis that could be found. They both had some derangement of the female organs which required operation for correction and soon after these operations the scleritis disappeared and up to the present time has remained cured.

Dr. J. E. Colburn, Chicago.—I would like to offer one suggestion regarding the treatment, and that is the climatic. I have had a few cases and have noticed that the most severe exacerbations usually came, as in choroiditis, in the spring, beginning in March and continuing during April and May. One patient invariably had a return of the attack during these months, and at my suggestion she went to California about mid-winter four years ago and escaped the recurrence. An opportunity occurred for her to go to Hawaii, where she has remained for three years. In a letter from her recently she said she had no return of the conditions. She had the colored spots on the sclera and I had her under observation for a number of years. I tried everything ever recommended for this disease before suggesting climatic change.

Dr. Alt (closing discussion).—I perfectly agree with Dr. Reynolds as to the meaning of the word "epi," but it has been the custom to call the tissue which lies upon the sclera and connects the conjunctival tissue with it, the episcleral tissue. As I have described, and as you see in the photographs, in episcleritis the inflammation lies in this tissue which unites the two membranes together and therefore it is right to call it an episcleritis. In these cases there is no inflammation to be found in the uveal tract. As regards syphilis being the underlying cause in most cases, I may ask in what disease may we not find some form of spyhilis present? How can you prove it and how can you disprove it? Dr. Donovan must have a good sense of smell if he can diagnose scleritis from the odor. At any rate, as he stated that he has been successful with phosphate of sodium, we should give it a trial. Dr. Suker said I had not mentioned salicylates. He was evidently not present when I read the paper. I am sorry that in the whole discussion I have heard only repetition of what I have said, excepting from Dr. Donovan. No one

seems to have better success than I, yet let us hope that the future will bring it. Dr. Minor mentioned the female sexual organs as possibly having some effect. I also mentioned this and said that in one case exacerbations took place with each menstrual period. I also send my patients to the general practioner whenever the eye trouble seems to be connected with some general disease and have them thoroughly examined. With regard to the climatological treatment, I have no experience, but it is interesting to hear Dr. Colburn's statement. It may be that the hot climate in those countries acts as a beneficial factor. Heat or sweating in some cases are very beneficial.

Operation for Detachment of the Retina.—At the meeting (April 24th, 1903) of the Society of Physicians of Vienna (Austria), Dr. Leopold Müller presented a patient on whom he had successfully treated a retinal detachment by means of an operation of his own invention. Up to 1891 the patient had had a myopia of 9 D., when he suddenly became blind in one eye from detachment. One year later, all other methods of treatment having failed, the author operated on that eye, as he has since done successfully in six other cases. After the temporary resection of the temporal orbital wall (after Kroenlein), he cut a piece of sclerotic, 10 by 20 mm. from its anterior temporal part, without wounding the choroid. Near the lowest angle of the wound a small knife was then pushed through the choroid and the subretinal fluid let out while the sutures previously introduced were being tied. Before the operation the patient could count fingers downwards only, while aside from a small central scotoma, he has now a normal field and counts fingers at 3 m. In two other cases the results have remained the same in 11, resp. 15 months. The author is inclined to recommend this method in those cases of high myopia in which the macula is endangered. The refraction in the case presented changed from a myopia of 9 D. to a hypermetropia of 4 D.—*Wiener klin. Rundschau.*